INDOOR AIR QUALITY ASSESSMENT

Samoset Middle School
100 DeCicco Drive
Leominster, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response Indoor Air Quality Program
September 2005

Background/Introduction

At the request of the Leominster Health Department (LHD), the Massachusetts Department of Public Health's (MDPH) Center for Environmental Health (CEH) provided assistance and consultation regarding indoor air quality at Leominster's public schools. These assessments were jointly coordinated through Chris Knuth, Director of the LHD, and David Wood, Facilities Director for Leominster Public Schools (LPS). On June 16, 2005, Cory Holmes, an Environmental Analyst in CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program, conducted an assessment at the Samoset Middle School (SMS), 100 DeCicco Drive, Leominster, Massachusetts as part of the overall assessment of the Leominster public schools.

The SMS is red brick building constructed from 1994 to 1995; it consists of a single story and a two-story wing. The second floor contains general classrooms, art room and office space. The first floor contains general classrooms, auditorium, gymnasium, kitchen, cafeteria, library, computer rooms, music room and office space. Windows are openable throughout the building.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Hnu, Model 102 Snap-on Photo Ionization Detector (PID). Moisture content of carpeting in the library was measured with a Delmhorst, BD-2000 Model, Moisture Detector. CEH staff also performed a visual inspection of building materials for water damage and/or microbial growth.

Results

The SMS houses grades 5 through 8, with a student population of approximately 600 and a staff of approximately 70. Tests were taken under normal operating conditions, however a number of classrooms were unoccupied due to end of the year activities (e.g., field trips, assemblies). Test results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were elevated above 800 parts per million parts of air (ppm) in eleven of forty areas surveyed, indicating inadequate air exchange in several areas on the day of the assessment. The majority of these areas were located in the two-story wing, where several exhaust vents were not operating. It is also important to note that a number of areas with carbon dioxide levels below 800 ppm were sparsely populated, unoccupied and/or had windows open. Low occupancy and open windows can greatly reduce carbon dioxide levels. Carbon dioxide levels would be expected to be higher with increased occupancy and with windows shut.

Fresh air in exterior classrooms is supplied by a unit ventilator (univent) system equipped with high efficiency pleated filters (Pictures 1 and 2). Univents are designed to draw air from outdoors through a fresh air intake located on the exterior walls of the building (Picture 3). Return air is drawn through an air intake located at the base of each unit (Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. All univents were operating during the assessment; however obstructions to airflow, such as papers and books stored on univents and bookcases, carts and desks in front of univent returns, were seen in a few classrooms (Picture 4). In order for univents to provide fresh air as designed, units must remain free of obstructions.

Exhaust ventilation in classrooms is provided by wall-mounted vents powered by rooftop motors (Picture 5). Exhaust vents did not appear to be functioning in a number of classrooms in the two-story wing (Table 1), which can indicate that motors were deactivated or non-functional. A number of exhaust vents were also obstructed by desks, bookcases and other items (Picture 6). As with the univents, in order to function properly, exhaust vents must be activated and remain free of obstructions. In addition, the location of some exhaust vents can limit exhaust efficiency. In several rooms, exhaust vents are located near hallway doors (Picture 5). With hallway doors open, exhaust vents in these rooms will tend to draw air from both the hallway and the classroom, reducing the effectiveness of the exhaust vent to remove common environmental pollutants.

Mechanical ventilation in interior rooms, and common areas such as the cafeteria, library and gym, is provided by rooftop air handling units (AHUs). Fresh air is drawn into outside air intakes and distributed to occupied areas via ductwork connected to ceiling-mounted air diffusers (Picture 7). Exhaust ventilation is provided by ceiling-mounted exhaust grills that are ducted back to AHUs. These AHUs were operating during the assessment.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a univent and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). Mr. Wood reported that the LPS has a contract with Pioneer Valley Environmental, Inc., an engineering firm, for the company to conduct preventive maintenance on heating, ventilation and air-conditioning (HVAC) equipment in all of Leominster's public schools. The preventative maintenance program consists of an annual assessment of all HVAC system components (e.g., univents, AHUs, pneumatic controls, thermostats). A detailed report is generated and provided to the LPS facilities department to enable the LPS staff to address HVAC needs.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information on carbon dioxide see Appendix A.

The assessment occurred on a day of unseasonably cool weather, where the outside temperature was 58 °F. Indoor temperature readings on the day of the assessment ranged from 70 °F to 74 °F, which were within the MDPH comfort guidelines. The MDPH recommends that indoor air temperatures be maintained in a range of 70 °F to 78 °F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity ranged from 44 to 56 percent, which were also within the MDPH recommended comfort range the day of the assessment. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

The ceiling-mounted air conditioning (AC) unit in the library has experienced leaks due to condensation (Picture 8). Occupants reported that the school's HVAC vendor had been in the building several days prior to the MDPH assessment to repair the AC unit. The carpeted area beneath the AC unit had signs of water damage. To determine if the carpeting had been thoroughly dried, CEH staff performed moisture testing of carpeting directly beneath the AC unit. As indicated, moisture content was measured with a Delmhorst Moisture Detector equipped with a Delmhorst Standard Probe. The Delmhorst probe is equipped with three lights that function as visual aids that indicate moisture level. Readings that activate the green light indicate a sufficiently dry or low moisture level, those that activate the yellow light indicate borderline conditions and those that activate the red light indicate elevated moisture content. No elevated moisture readings were measured during the assessment (Table 1).

A few areas had water-stained ceiling tiles, which can indicate leaks from the roof or plumbing system. Water-damaged ceiling tiles can provide a source for mold and should be replaced after a water leak is discovered and repaired. Open seams between the sink countertop and backsplash were observed in several rooms (Picture 9). If not watertight, water can penetrate through the seam, causing water damage. Water penetration and chronic exposure of porous and wood-based materials can cause these materials to swell and show signs of water damage.

Plants were noted in several classrooms, and shrubbery was seen in close proximity to univent air intakes (Pictures 3 and 10). Plants can be a source of pollen and mold, which can be respiratory irritants for some individuals. Plants should be properly maintained and equipped with drip pans. Plants should also be located away from ventilation sources (e.g., air intakes, univent diffusers) to prevent the entrainment and/or aerosolization of dirt, pollen or mold.

A number of aquariums and terrariums were observed in classrooms (Picture 11). Aquariums should be properly maintained to prevent microbial/algae growth, which can emit unpleasant odors. Similarly, terrariums should be properly maintained to ensure soil does not become a source for mold growth.

Other IAQ Evaluations

Indoor air quality can be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, CEH staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide pollution and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient-Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. *Carbon monoxide should not be present in a typical, indoor environment.* If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were non-detect or ND (Table 1). Carbon monoxide levels measured in the school were also ND (Table 1).

Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits for particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000a). This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particulate levels be maintained below 65 $\mu g/m^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the

PM10 standard for evaluating air quality, the MDPH uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 27 μg/m^3 (Table 1). PM2.5 levels measured indoors ranged from 6 to 31 μg/m^3 (Table 1). Although PM2.5 measurements were slightly above background in some areas, they were below the NAAQS of 65 μg/m^3. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be impacted by the presence of materials containing volatile organic compounds (VOCs). VOCs are substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. Outdoor air samples were taken for comparison. Outdoor TVOC concentrations were non-detect (ND) (Table 1). Indoor TVOC measurements throughout the building were also ND (Table 1).

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use

TVOC containing products (e.g., the concentration of TVOCs within a classroom increases when the product is in use). Dry erase markers were seen in several classrooms. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, (e.g. methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999). Cleaning products and air deodorizers were found on countertops in some classrooms. Like dry erase materials, cleaning products contain VOCs and other chemicals that can be irritating to the eyes, nose and throat of sensitive individuals.

Several other conditions that can affect indoor air quality were noted during the assessment. Of note was the amount of materials stored inside some classrooms. In several areas, items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Fan blades to personal fans in a number of areas were observed to be covered with dust. Reactivated fans can serve to distribute accumulated dust. Dust can be irritating to the eyes, nose and respiratory tract.

Finally, a number of bee/hornets nests were observed around the perimeter of the building, some near univent air intakes (Picture 12). These nests should be removed in a manner as to not introduce pesticides and/or insects into the building. Under current Massachusetts law that, effective November 1, 2001, the principles of integrated pest management (IPM) must be used to remove pests in state buildings and grounds (Mass Act, 2000).

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made to improve general indoor air quality:

1. Work with an HVAC engineer concerning the operability of rooftop exhaust vents in the two-story wing.
2. Use openable windows in conjunction with classroom exhaust vents to facilitate air exchange. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
3. Remove all blockages from univents and exhaust vents to ensure adequate airflow.
4. Close classroom doors to maximize air exchange.
5. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
6. Ensure leaks are repaired, and replace water damaged ceiling tiles. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial. Particular attention should be made to water damage in the library (e.g., ceiling tiles and carpeting).
7. Ensure plants have drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary. Remove plants from the air stream of univents.
8. Clear plant growth away from the proximity of univent air intakes.

9. Clean and maintain aquariums and terrariums to prevent mold growth and associated odors.
10. Seal areas around sinks to prevent water damage to the interior of cabinets and adjacent wallboard.
11. Store cleaning products properly and out of reach of students.
12. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning of classrooms. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
13. Remove nests in a manner consist with the principles of IPM (Mass Act, 2000). An IPM implementation booklet is available from the Department of Agriculture: http://www.mass.gov/agr/pesticides/publications/IPM_kit_for_bldg_mgrs.pdf.
14. Consider adopting the US EPA (2000b) document, "Tools for Schools", to maintain a good indoor air quality environment on the building. This document can be downloaded from the Internet at: http://www.epa.gov/iaq/schools/index.html.
15. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website at: http://mass.gov/dph/indoor_air.

References

ASHRAE. 1989. Ventilation for Acceptable Indoor Air Quality. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 62-1989

BOCA. 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL.

Mass. Act. 2000. An Act Protecting Children and families from Harmful Pesticides. 2000 Mass Acts c. 85 sec. 6E.

MDPH. 1997. Requirements to Maintain Air Quality in Indoor Skating Rinks (State Sanitary Code, Chapter XI). 105 CMR 675.000. Massachusetts Department of Public Health, Boston, MA.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

Sanford. 1999. Material Safety Data Sheet (MSDS No: 198-17). Expo® Dry Erase Markers Bullet, Chisel, and Ultra Fine Tip. Sanford Corporation, Bellwood, IL.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0.

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

US EPA. 2000a. National Ambient Air Quality Standards (NAAQS). . US Environmental Protection Agency, Office of Air Quality Planning and Standards, Washington, DC. http://www.epa.gov/air/criteria.html.

US EPA. 2000b. Tools for Schools. Office of Air and Radiation, Office of Radiation and Indoor Air, Indoor Environments Division (6609J). EPA 402-K-95-001, Second Edition. http://www.epa.gov/iaq/schools/tools4s2.html

Picture 1

Typical Classroom Univent

Picture 2

Ceiling-Mounted Univent in First Floor Classroom

Picture 3

Univent Fresh Air Intake, Note Plant Growth in Close Proximity

Picture 4

Univent Air Diffuser Obstructed by Various Items

Picture 5

Classroom Exhaust Vent, Note Open Hallway Door

Picture 6

Exhaust Vent Obstructed by Trash Barrel

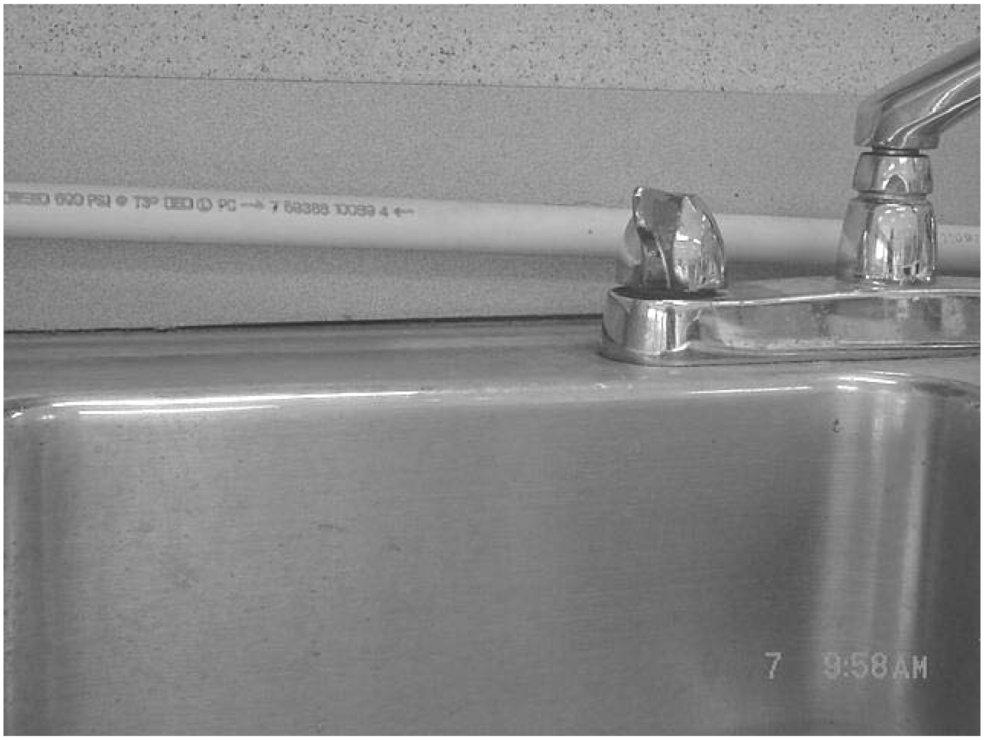
Picture 7

Ceiling-Mounted Multi-Directional Air Diffuser

Picture 8

Bucket Stationed beneath Leaking AC Unit in Library

Picture 9



Breach between Sink Countertop and Backsplash

Picture 10

Plants Near the Airstream of Univents

Picture 11

Empty Aquarium in Classroom with Algae/Mold Growth Interior

Picture 12

Hornet/Bees Nest in Univent Air intake

Samoset Middle School **Indoor Air Results**

281 100 DeCicco Drive, MA 01453 **June 16, 2005**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
background		58	60	399	ND	ND	27				Mostly cloudy, unseasonably cool.
music	24	70	56	790	ND	ND	20	N	Y ceiling	Y ceiling	Hallway DO, window-mounted AC,
library	2	70	51	600	ND	ND	8	Y # open: 0 # total: 20	Y ceiling	Y ceiling	Inter-room DO, WD-carpet, leaking AC-bucket to catch leaks, repaired-carpet moisture: low.
computer room	12	72	52	749	ND	ND	17	N	Y ceiling	Y wall	Inter-room DO, DEM.
124	18	73	52	790	ND	ND	19	Y # open: 0 # total: 8	Y univent	Y wall	Hallway DO, DEM, PF.
123	10	73	50	760	ND	ND	26	Y # open: 1 # total: 8	Y univent	Y wall items	Hallway DO,

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium
AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials
design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WD = water damage
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Samoset Middle School | **Indoor Air Results**

281 100 DeCicco Drive, MA 01453 | **June 16, 2005**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (μg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
126	24	73	51	802	ND	ND	21	Y # open: 2 # total: 8	Y univent	Y wall	Hallway DO, DEM.
127	20	74	53	1200	ND	ND	23	Y # open: 0 # total: 8	Y univent	Y wall	Hallway DO, DEM.
gym	6	71	46	620	ND	ND	23	Y # open: 0 # total: 22	Y ceiling	Y ceiling	Exterior DO,
208	1	72	47	658	ND	ND	27	Y # open: 0 # total: 8	Y univent	Y (off)	Hallway DO, DEM, PF, temperature complaints (hot), temp complaints (heat) from solar glare.
128	26	73	50	797	ND	ND	29	Y # open: 0 # total: 8	Y univent	Y wall	Hallway DO, DEM, PF.

ppm = parts per million
μg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WD = water damage
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Samoset Middle School
281 100 DeCicco Drive, MA 01453

Indoor Air Results
June 16, 2005

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
125	26	74	51	798	ND	ND	29	Y # open: 0 # total: 8	Y univent	Y wall	Hallway DO, DEM, PF.
205	0	72	46	674	ND	ND	16	Y # open: 0 # total: 8	Y univent	Y wall (off) boxes items furniture	Hallway DO, DEM.
204	0	72	44	467	ND	ND	6	Y # open: 0 # total: 8	Y univent plant(s)	Y wall (off)	DEM.
202	0	71	44	447	ND	ND	17	Y # open: 0 # total: 8	Y univent	Y wall	DEM.

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WD = water damage
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Samoset Middle School **Indoor Air Results**

281 100 DeCicco Drive, MA 01453 **June 16, 2005**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
201	5	73	45	664	ND	ND	17	Y # open: 0 # total: 6	Y univent items	Y (off)	Hallway DO, vented kiln.
203	0	74	45	642	ND	ND	10	Y # open: 0 # total: 2	Y univent	Y wall (off) items	Hallway DO, DEM, PF.
207	20	74	48	1002	ND	ND	18	Y # open: 3 # total: 4	Y univent	Y wall (off)	DEM, PF.
214	1	72	45	750	ND	ND	17	Y # open: 0 # total: 8	Y univent	Y wall	Hallway DO, DEM, PF.
216	0	73	44	618	ND	ND	13	Y # open: 2 # total: 8	Y univent plant(s)	Y wall	Hallway DO, DEM, PF.

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WD = water damage
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Samoset Middle School | **Indoor Air Results**

281 100 DeCicco Drive, MA 01453 | **June 16, 2005**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
217	0	72	44	660	ND	ND	13	Y # open: 0 # total: 0	Y univent	Y wall	DEM, PF, cleaners.
213	5	72	47	807	ND	ND	20	Y # open: 0 # total: 8	Y univent	Y wall	DEM, PF.
218	1	71	46	737	ND	ND	14	Y # open: 0 # total: 8	Y univent	Y	Hallway DO, DEM, PF.
212 PT/OT	2	73	46	779	ND	ND	13	Y # open: 0 # total: 4	Y univent	Y wall	Hallway DO, DEM.
guidance (Derry)	1	73	46	680	ND	ND	23	Y # open: 1 # total: 4	N	N	DEM, PF.

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WD = water damage
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Samoset Middle School

281 100 DeCicco Drive, MA 01453

Table 1

Indoor Air Results

June 16, 2005

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
school psychologist	0	73	44	636	ND	ND	15	Y # open: 0 # total: 6	N	N	Hallway DO, window-mounted AC,
210	0	73	45	666	ND	ND	19	Y # open: 0 # total: 8	N	N	Hallway DO, DEM.
118	0	72	46	674	ND	ND	9	N # open: 0 # total: 0	Y ceiling	Y ceiling	Hallway DO,
117	2	72	46	586	ND	ND	14	Y # open: 0 # total: 5	Y univent	Y wall items	window-mounted AC, DEM.
116	21	72	49	761	ND	ND	21	Y # open: 2 # total: 8	Y univent	Y wall	Hallway DO, DEM, PF.

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WD = water damage
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Samoset Middle School **Indoor Air Results**

281 100 DeCicco Drive, MA 01453 **June 16, 2005**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
115	27	73	53	1273	ND	ND	26	Y # open: 0 # total: 8	Y univent	Y wall	DEM, PF.
114	23	74	53	1420	ND	ND	20	Y # open: 0 # total: 8	Y univent items	Y wall	DEM, PF.
111	4	73	47	763	ND	ND	18	Y # open: 0 # total: 4	Y univent	Y wall	Hallway DO, DEM, PF.
108	0	73	49	1042	ND	ND	17	Y # open: 0 # total: 8	Y univent	Y wall (off)	Hallway DO, DEM, PF, occupants @ lunch.
105	5	73	48	889	ND	ND	12	Y # open: 0 # total: 4	Y univent	Y wall (off)	DEM.

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WD = water damage
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Samoset Middle School | **Indoor Air Results**

281 100 DeCicco Drive, MA 01453 | **June 16, 2005**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (μg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
104	4	73	48	875	ND	ND	14	Y # open: 0 # total: 4	Y univent	Y wall	DEM, PF.
103	0	73	49	1028	ND	ND	13	Y # open: 0 # total: 8	Y univent ceiling	Y wall (off)	Hallway DO, DEM, PF.
107	0	73	48	746	ND	ND	31	Y # open: 1 # total: 6	Y univent	Y wall (off) items	Hallway DO, DEM, PF.
102	0	72	47	714	ND	ND	22	Y # open: 1 # total: 8	Y univent	Y wall (off)	Hallway DO, occupants @ lunch.
101	0	72	50	975	ND	ND	14	Y # open: 0 # total: 6	Y univent	Y wall (off) items	Hallway DO, DEM, PF, occupants @ lunch.

ppm = parts per million
μg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WD = water damage
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Samoset Middle School | **Indoor Air Results**

281 100 DeCicco Drive, MA 01453 | **June 16, 2005**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (μg/m3)	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
cafeteria	100	73	48	697	ND	ND	20	N	Y univent	Y ceiling	Hallway DO,

ppm = parts per million
μg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WD = water damage
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%